



Methane: Its Role as a Greenhouse Gas

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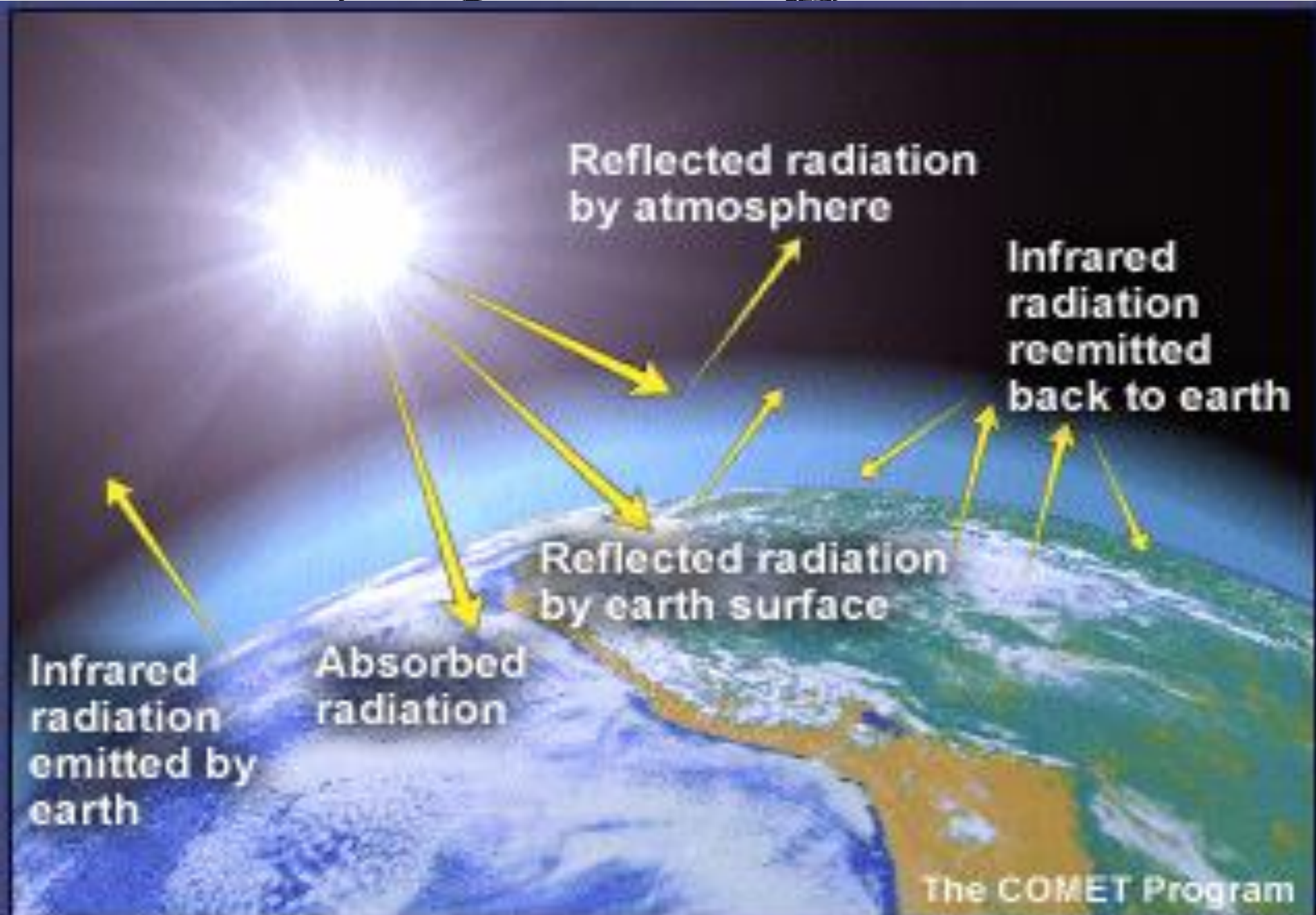
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Pasadena, California
April 21, 2012

Outline

1. The Greenhouse Effect
2. The role of methane as a greenhouse gas
3. Methane Sources
4. Methane Concentrations
5. Conclusion

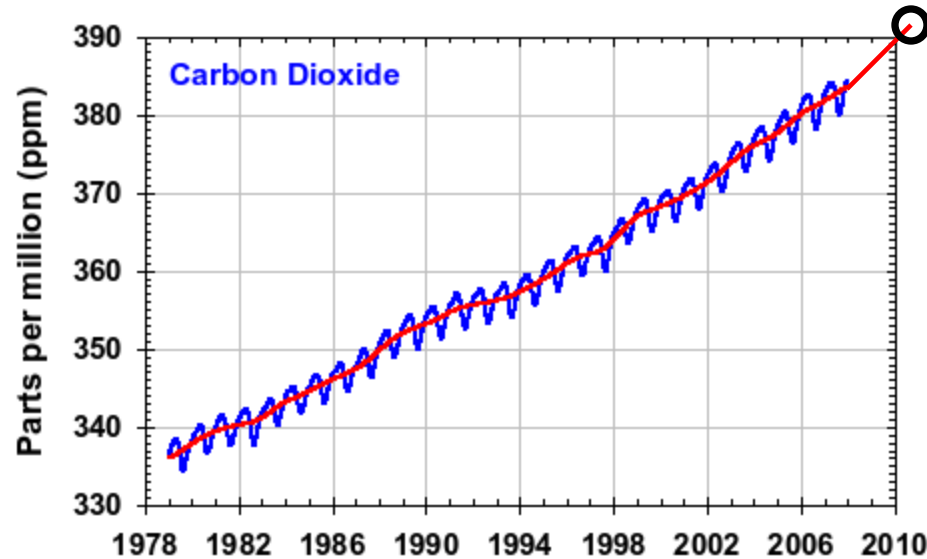


The Greenhouse Effect



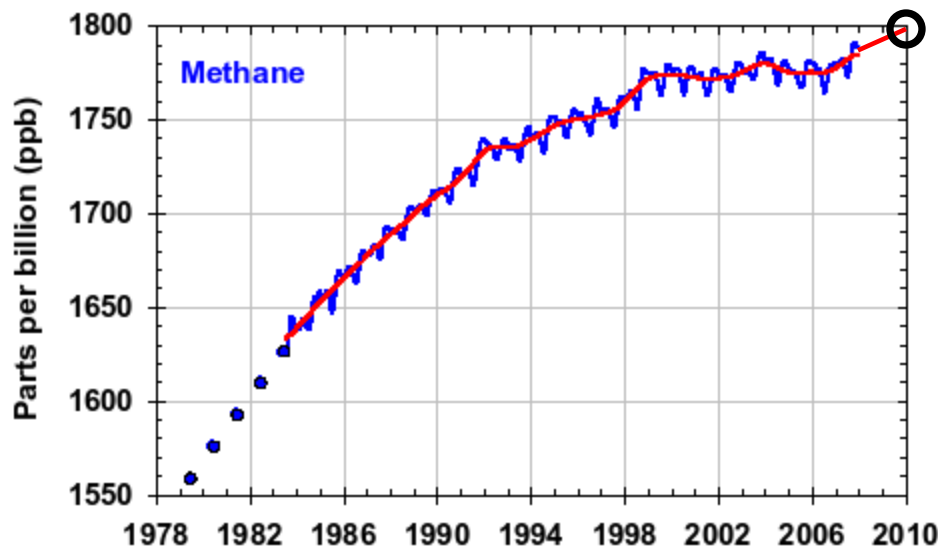
Atmospheric CO₂ and Methane Concentrations

current CO₂ levels: 394 ppm



Since the Industrial Revolution began in about 1750, CO₂ levels have increased nearly 40% as of 2012 and CH₄ levels have increased by almost 165%.

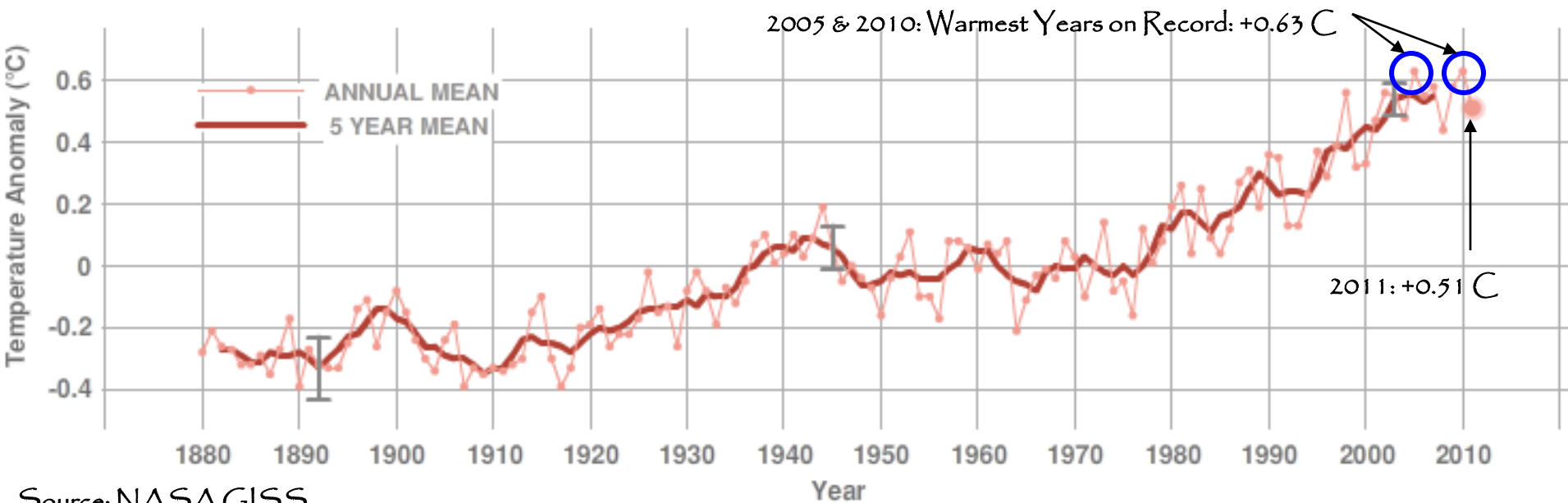
current CH₄ levels: 1800 ppb



Source: WMO

Result of the Greenhouse Effect: Increase in Global Temperature

Global Surface Temperature

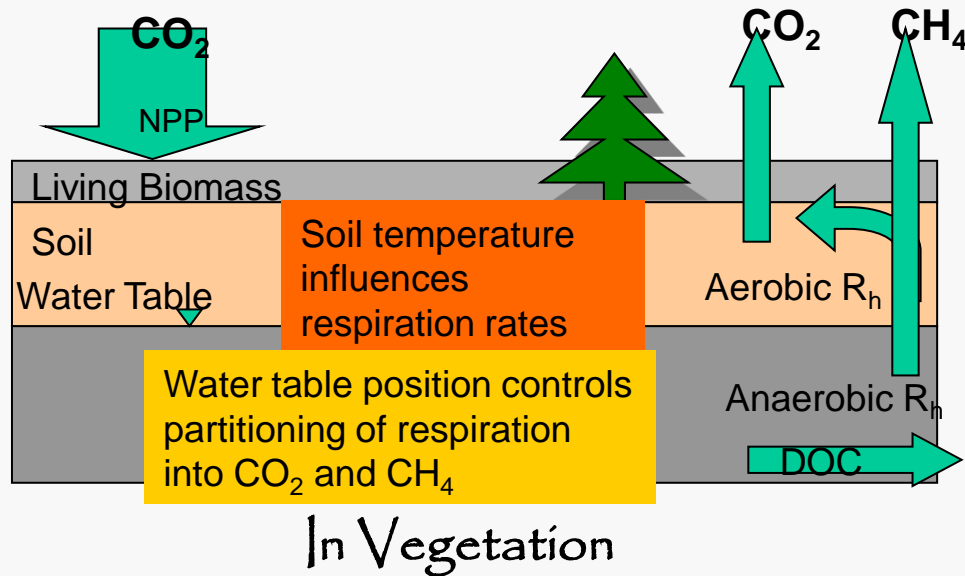


Source: NASA GISS

Global Temperature Anomaly

How is Methane Produced

Methanogenesis: the formation of methane by microbes known as methanogens.
It is produced anaerobically (without the presence of oxygen)



In Ruminants

Three conditions are needed to produce methane:

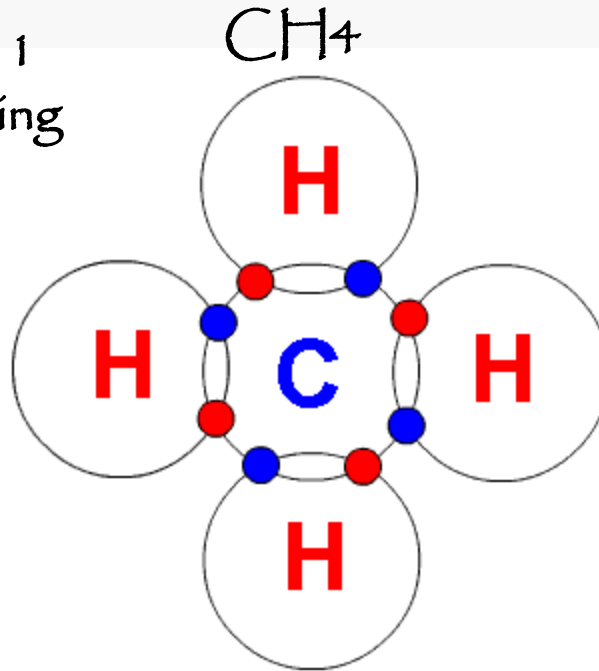
- (1) microorganisms,
- (2) (2) organic matter (i.e. dead plants) and
- (3) (3) an oxygen-free environment.

Methanogenesis occurs in the guts of humans and other animals, especially ruminants. In the rumen, anaerobic organisms digest cellulose into forms usable by the animal. Without these microorganisms, animals such as cattle would not be able to consume grass

Greenhouse Gasses and Methane

25x more potent than CO_2

If 1 tonne of CO_2 has a warming potential of 1, then 1 tonne of methane has a warming potential of 25

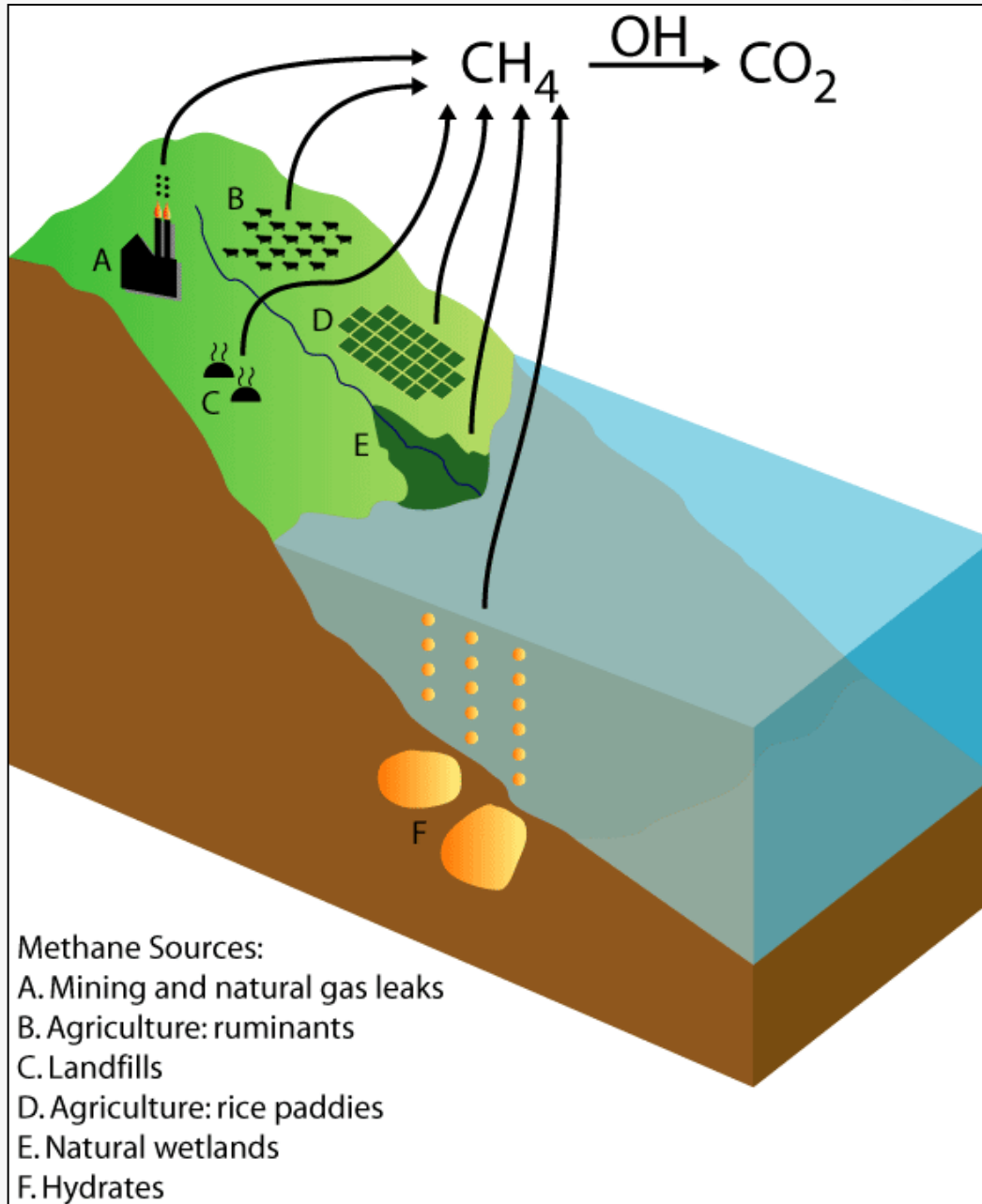


short lived: 8-12 years



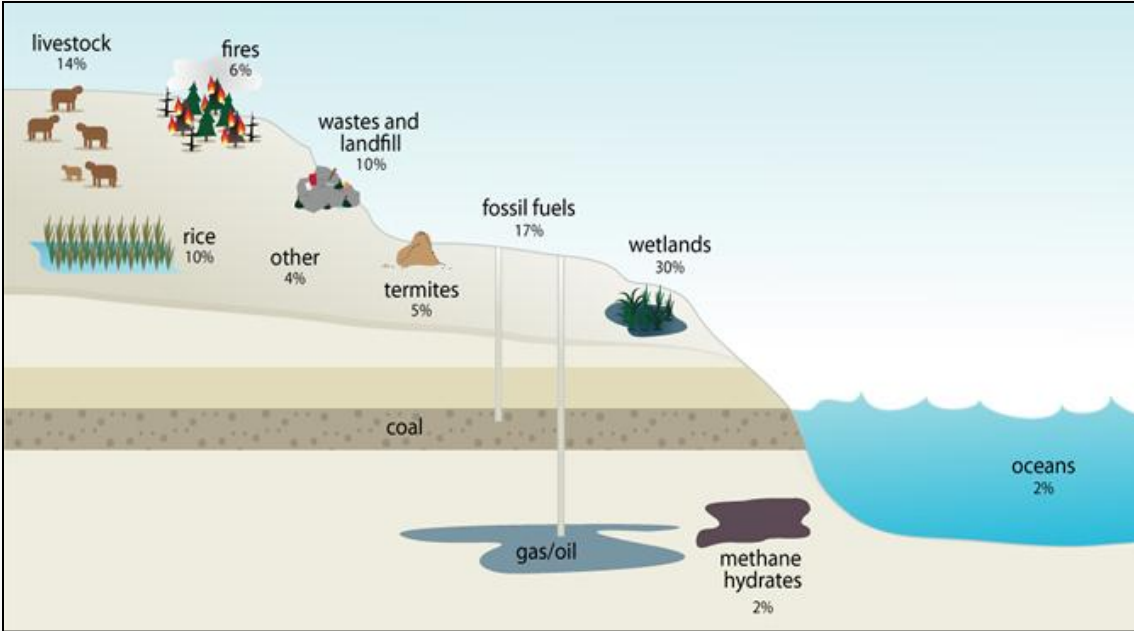
Even though methane has a low profile, it is responsible for about 20% of the enhanced greenhouse effect

Methane Cycle



Tropospheric destruction of methane by hydroxyl (OH) radicals is the dominant sink for atmospheric methane. Methane in the atmosphere is oxidized, producing carbon dioxide and water. Some microorganisms (methanotrophs) found in soils use methane as a source of carbon.

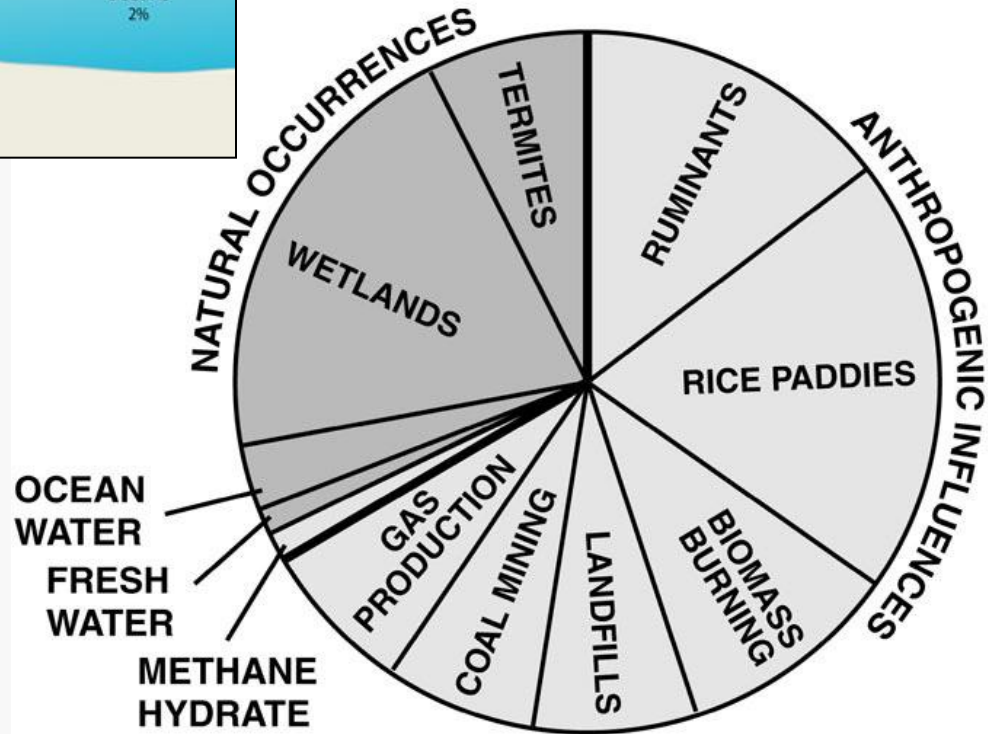
Methane Sources



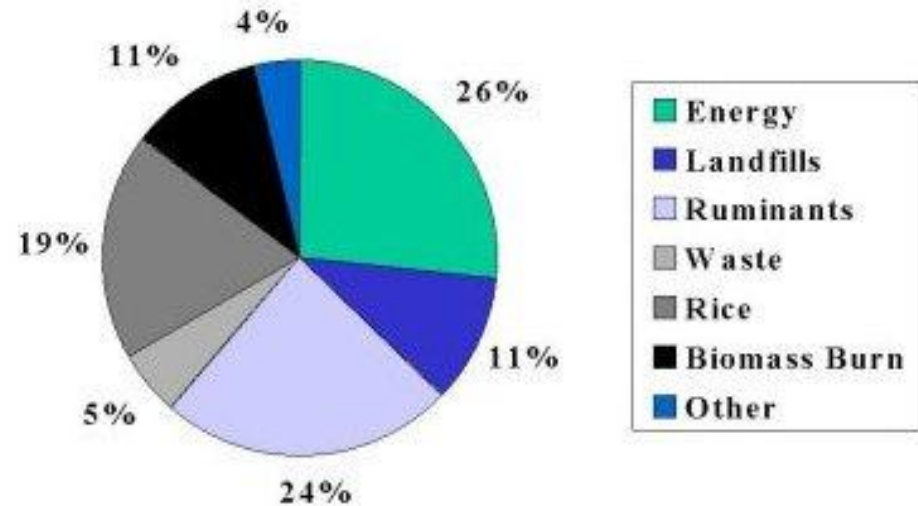
Although methane is not produced much by humans, compared to CO₂, we still do so through energy production, agriculture, keeping of livestock and from landfills.

Global emissions from natural sources total around 250 million tonnes each year.

Global emissions from man-made sources are the largest contributor. They total about 320 million tonnes each year.



Anthropogenic Sources of Methane



Energy related and ruminant methane dominate man-made methane sources.



Reducing Anthropogenic Methane Emissions

60 % of CH₄ is produced by human-related activities. Changing our ways could help to reduce the amount of CH₄ in the atmosphere:

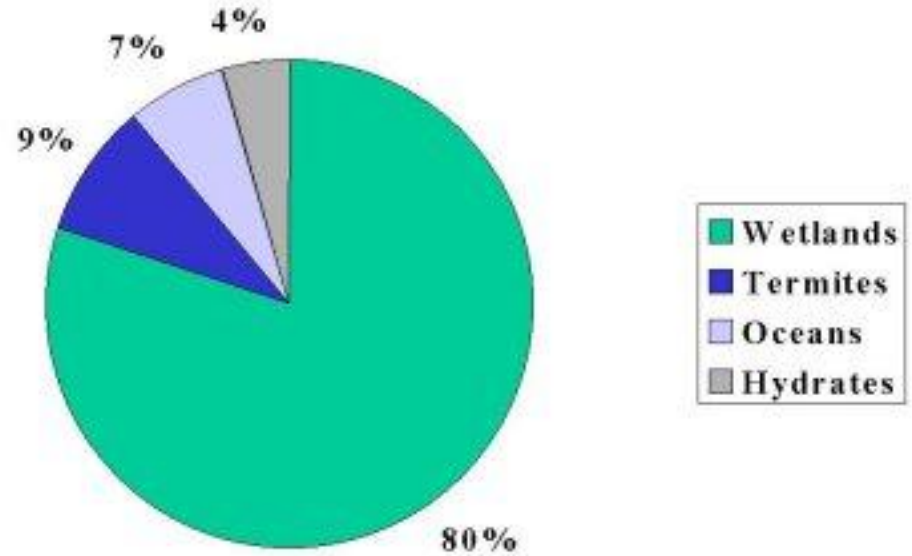
- Rice fields: dry rice farming; new rice varieties; draining and reflooding during growing season
- Landfills: planting trees to prevent rainwater accumulation; covering so that rainwater doesn't reach ground: less production of trash
- Livestock: better feed and better grazing management
- Fossil Fuels: reduce leaking transmission lines

Methane can have a big effect on climate change. Finding ways of reducing or reusing methane produced by human activities could be a relatively quick and easy way of reducing greenhouse gas emissions.

- collecting methane from landfills, oil refineries, and coal mines and using it as an energy source.

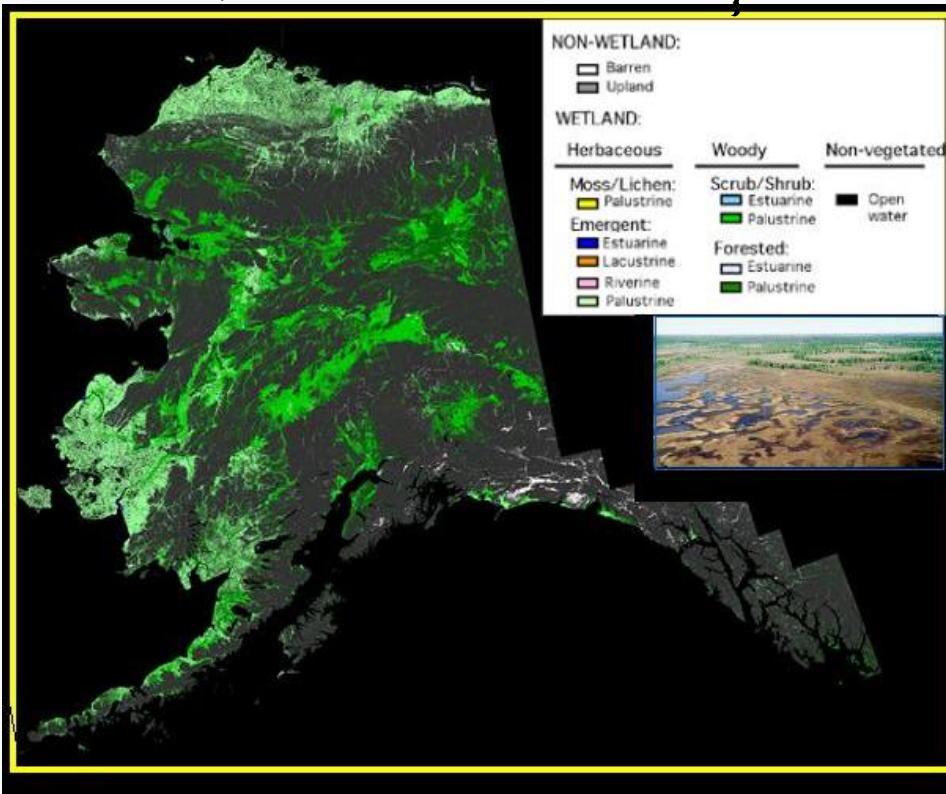


Natural Sources of Methane

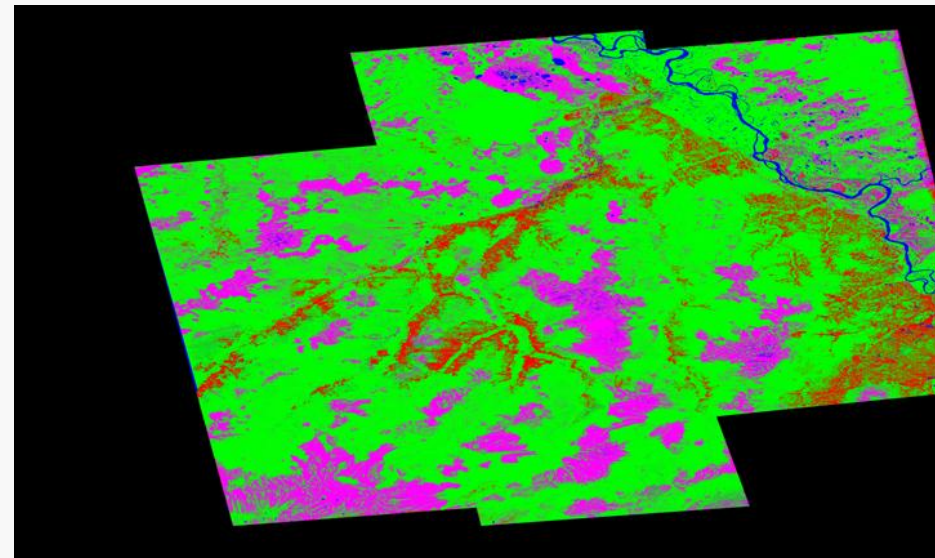
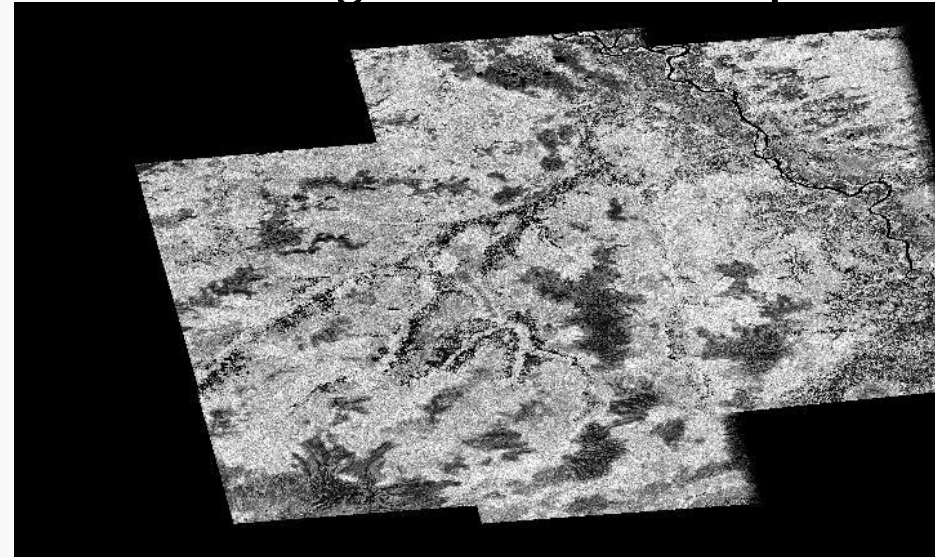


Wetlands

Alaska Wetland Map

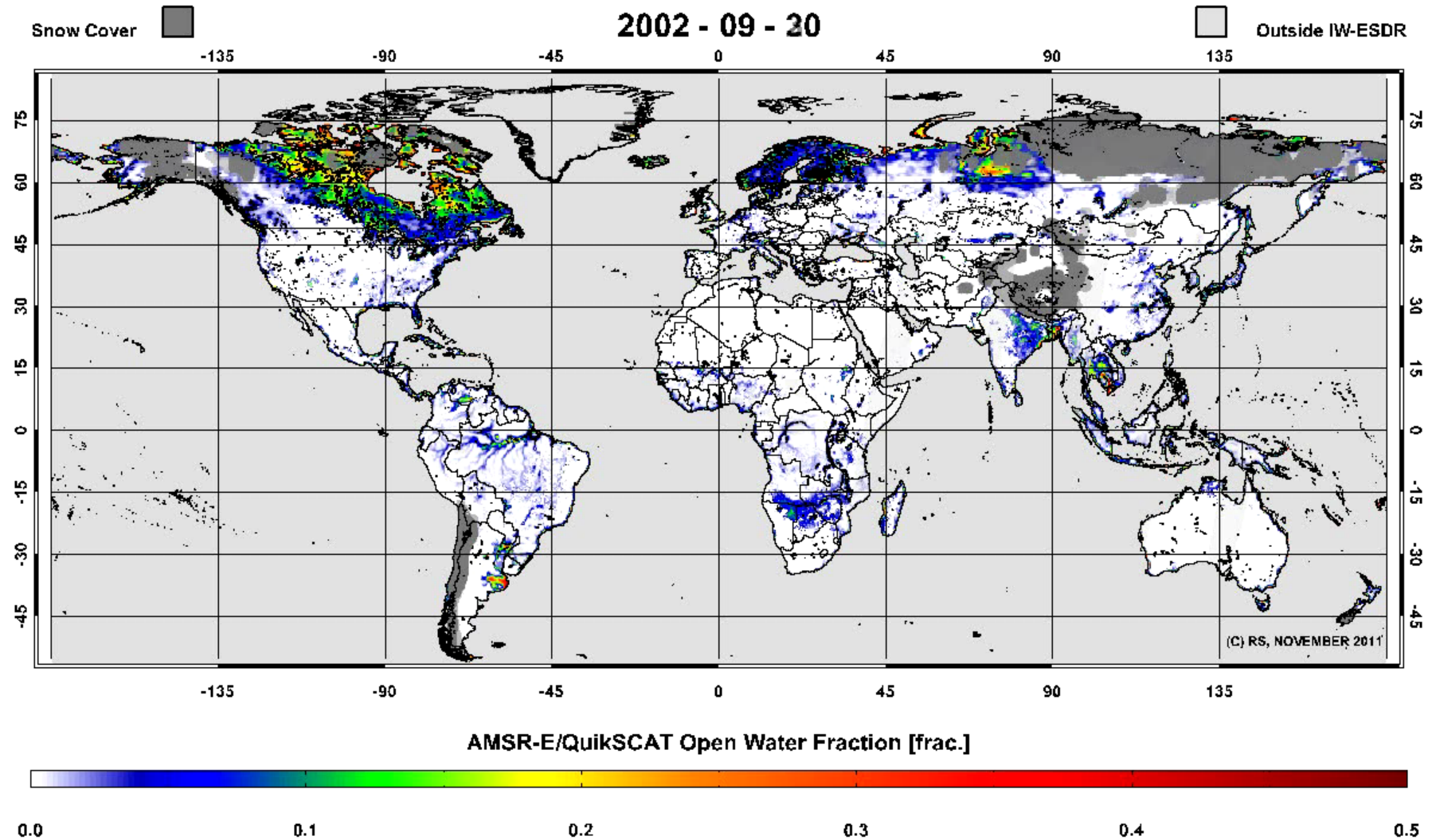


Chaya Wetland Map



Models have shown that a 1 degree increase in temperature may increase methane emissions from wetlands by about 20%-big impact.

Surface Inundation



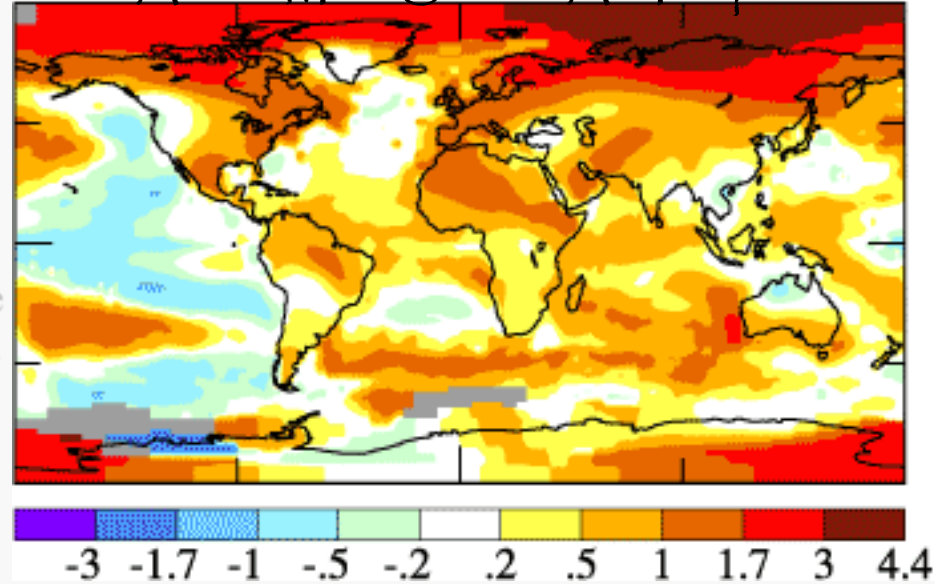
Soil Moisture Active Passive Mission (SMAP)

Methane in the Arctic

The Arctic is potentially a great source of methane production, having: temperature, organic matter availability and water.

These factors work together to create a complex picture for methane production. The concern is that methane levels may rise dramatically if global warming increases. Higher temperatures would cause melting of permafrost in the northern hemisphere. As organic matter from long-dead plants and animals is released from the thawing permafrost and becomes covered by water, more methane would be produced by microbes.

2011 Annual Mean Surface Air Temperature



Permafrost

Estimates suggests that the permafrost, which underlies nearly a quarter of the Northern Hemisphere, contains 2.5 times as much carbon as the entire atmosphere.

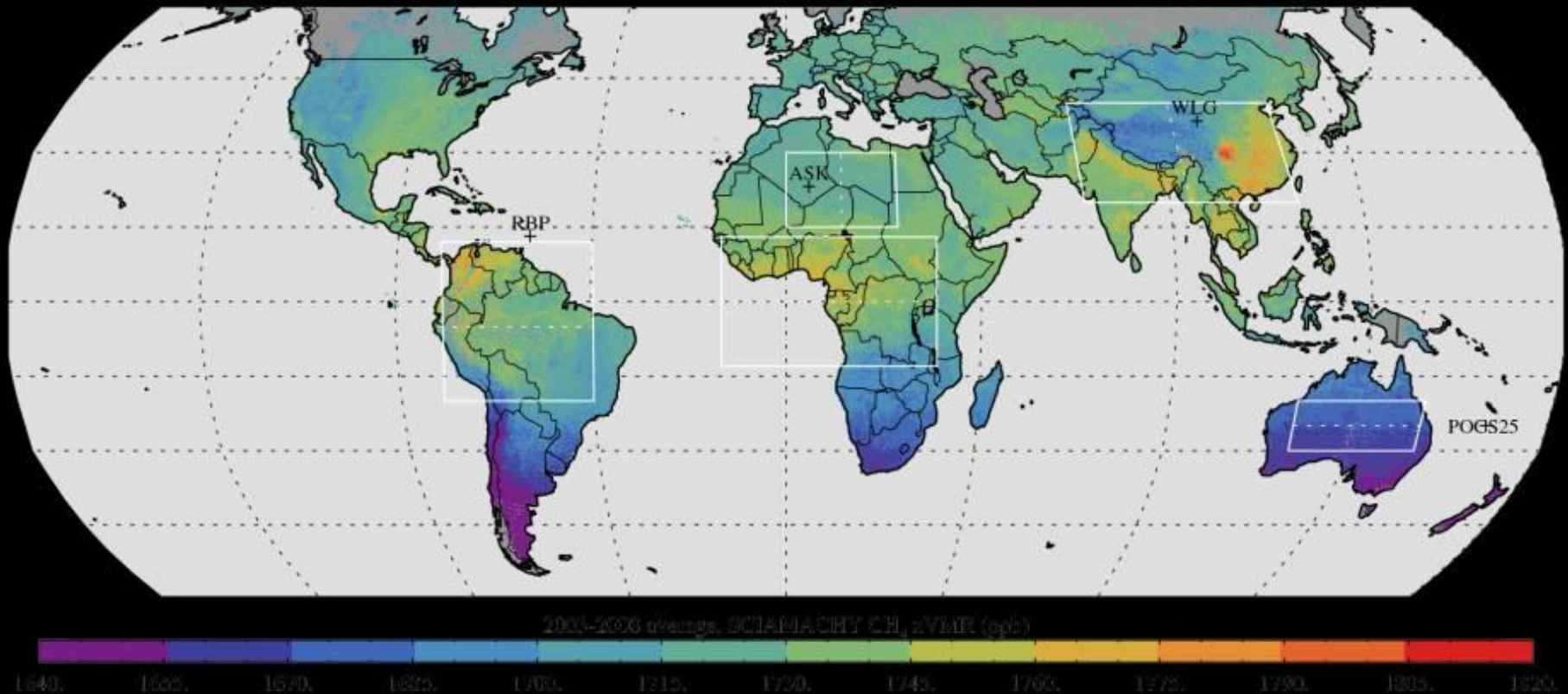
The potential for large new methane emissions in the Arctic is one of the biggest wild cards in climate science.

Studies estimate that if human fossil-fuel burning remained high and the planet warmed sharply, the gases from permafrost could eventually equal 35 percent of today's annual human emissions.



Methane Atmospheric Concentrations

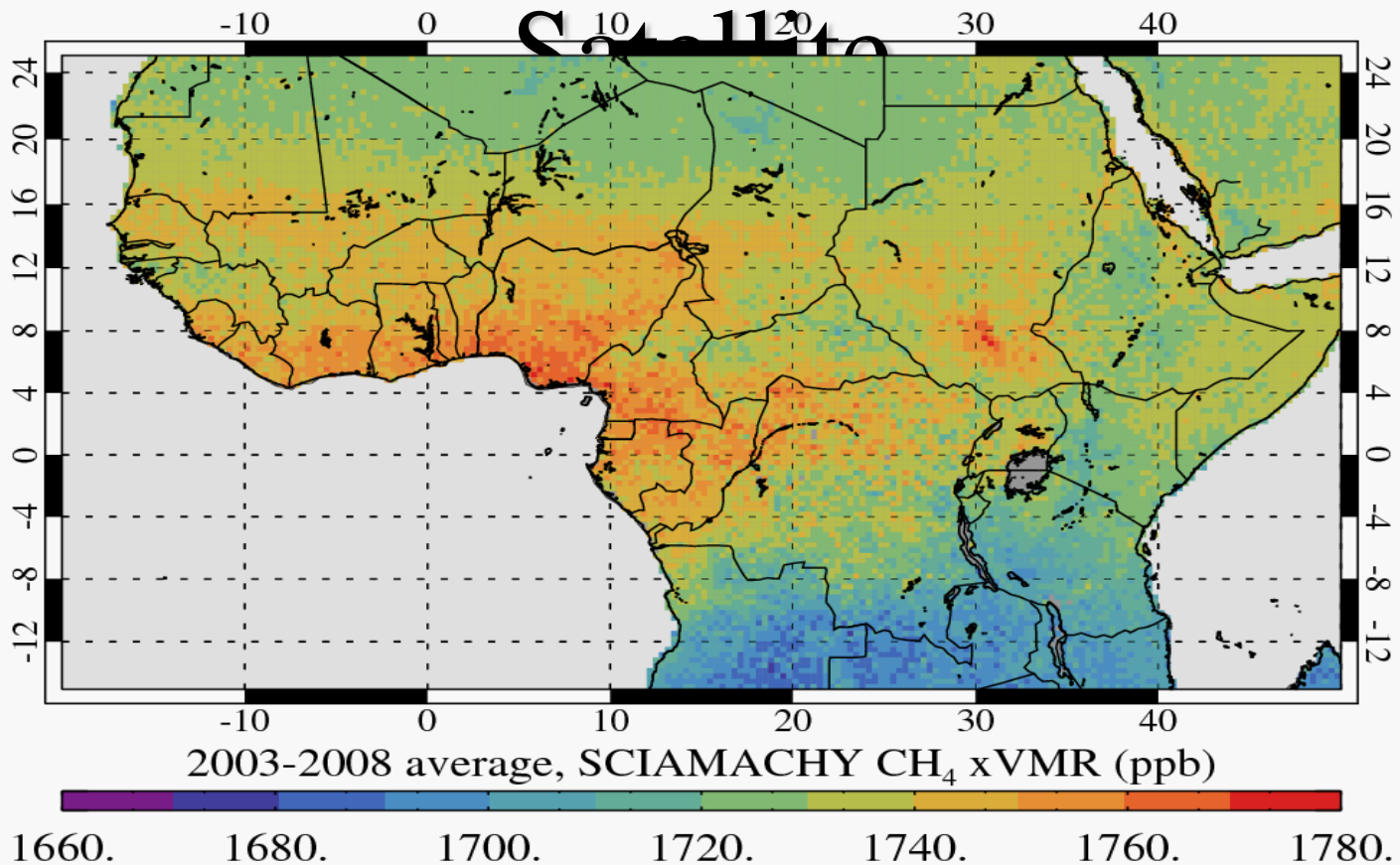
2003-2008 SCIAMACHY average



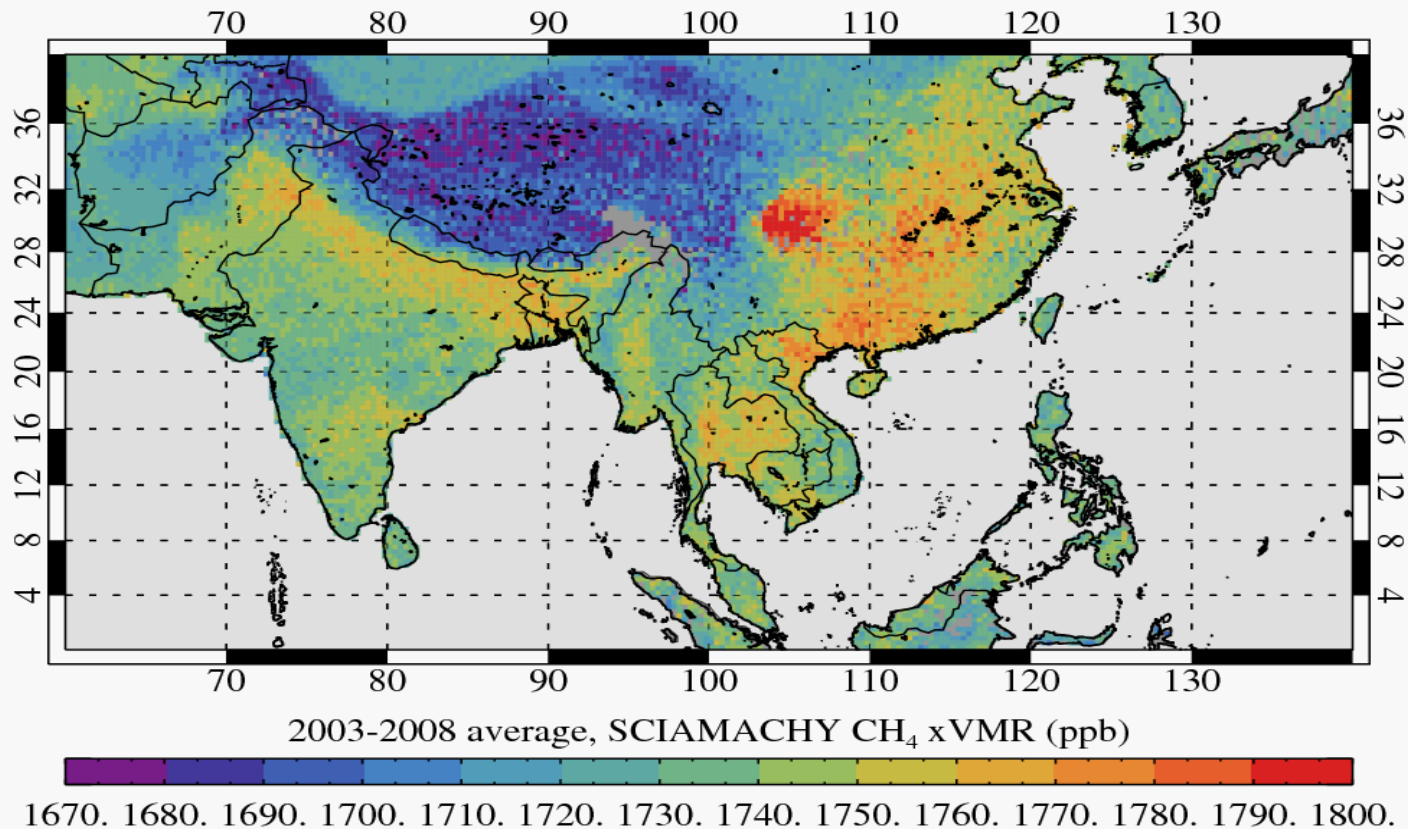
courtesy of Christian Frankenberg-JPL

Long Term Methane Emissions

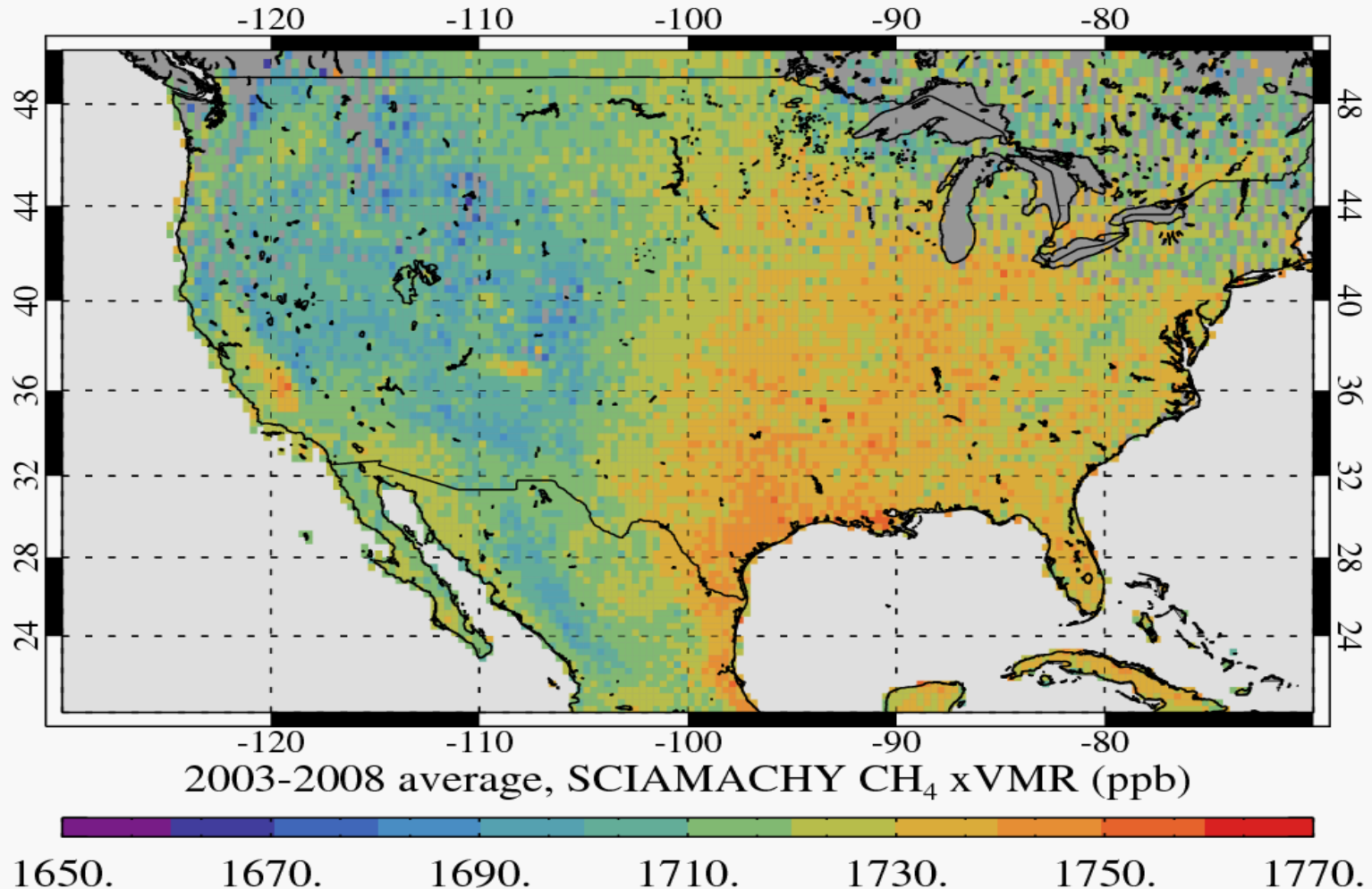
Average of Africa from the SCIAMACHY-ENVISAT



Long Term Methane Emissions Average of Asia from the SCIAMACHY-ENVISAT Satellite



Long Term Methane Emissions Average of North America from the SCIAMACHY-ENVISAT Satellite



Conclusions

- Global methane levels were relatively stable for a long time, because the total methane produced was being offset by natural methane removal methods, known as methane ‘sinks’. But atmospheric levels are now increasing (since 2007).
- Global budget (ie total source) relatively well constrained.
- Partitioning among sources still uncertain, esp. tropical regions.
- How does methane react to global warming (eg thawing of permafrost)?
- Anthropogenic?